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ABSTRACT

As part of a larger study of developmental deficits in the skills of automaticity of name retrieval, phonological awareness, and memory span and their role in reading disabilities, a study tested 13 average and 14 poor fourth-grade readers for digit and letter naming speed, phonological awareness, and digit span. Among the reading skills assessed were single word identification, word attack, and reading comprehension. The Peabody Picture Vocabulary Tests-Revised provided an estimate of verbal IQ. Reading comprehension was assessed by the Canadian Test of Basic Skills. Accuracy of single word reading and of nonsense word decoding were assessed by two subtests of the Woodcock Reading Mastery Test, Word Identification and Word Attack. Three phonological awareness tests were administered: (1) the Auditory Analysis Test; (2) the Odd Word Out task of Bradley and Bryant; and (3) a phonological task in which children repeated three- and four-syllable real and nonsense words pronounced by the examiner. Short term memory was assessed by the Digit Span subtest from the WISC-R (Wechsler Intelligence Scale for Children-Revised). Results indicated that digit naming speed, phonological awareness, and short term memory contributed variance to reading skills. However, phonological awareness tests were not intercorrelated and, with one exception, did not correlate with tests of naming speed or memory. (Six tables of data are included, and 23 references are appended.) (MM)

Naming Speed and Phonological Awareness: Independent Contributors to Reading Disabilites

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Reading is a very complex skill, requiring the quick coordination of many visual and verbal subprocesses. Attempts to understand what has "gone wrong" for those children who experience an unexpected failure to progress in learning to read have focussed recently upon the weakness many of these children show in phonological processing (Wagner & Torgesen, 1987). One aspect of such processing, phonological awareness, has been extensively investigated. Awareness -- as indicated by phoneme segmentation (eg., Ellis & Large, 1987), phoneme deletion (eg., Stanovich, Cunningham & Feeman, 1984), or categorizing words by their sounds (Bradley & Bryant, 1985) -- discriminates reading disabled and normal reading groups. Little is known about the intercorrelations of these measures. While we know that lack of phonological awareness is a route to reading failure, it is important not to overlook other cognitive processes that may also contribute to this disability.

LaBerge and Samuels (1974) argued that the content relevant to each successive stage of reading acquisition, from letter and syllable sounds to words and phrases, must be accessed not only accurately, but also relatively automatically, to allow processing resources to be used for other aspects of reading. For example, without relatively automatic word recognition, reading comprehension suffers (Perfetti, 1985). The ability to automatize the retrieval of names of visual material is thought to be reflected in a child's speed of naming very familiar items. Denckla and Rudel (1976) and Spring and Capps (1974) demonstrated that dyslexic children were significantly slower than normal readers in simple naming tasks, such as the naming of continuous lists of highly familiar numbers, letters, pictures of objects and color patches. Wolf, Bally & Morris (1986) showed that prereaders' speed of naming could predict their reading skill at the end of Grade 1 and 2.

Many other researchers have noted the poorer short term verbal memory of disabled readers. Whether such short term memory deficits are due to slow item identification (Dempster, 1981; Spring & Capps, 1974; Spring & Perry, 1983) or impoverished or inefficient phonetic coding in working memory (Shankweiler, et. al, 1979; Perfetti, 1985) or indeed to verbal intelligence differences (Bowers, Steffy & Tate, 1988) is unclear.

Very few researchers have studied phonological awareness (or the detection of sounds within words), naming speed, and short term memory in the same sample. Ellis & Large (1987) found that good and poor readers of similar IQ differed from each other on measures of these constructs; Mann (1984) found that tests assessing memory, naming and phonological awareness in kindergarten predicted first grade reading skill well, and the predictors were relatively independent of one another. Significant correlations between naming speed and short term auditory memory have been reported (Spring & Capps, 1974; Spring & Perry,

1983; Torgesen & Houck, 1980), although the strength of the relationship appears variable (Bowers, Steffy & Tate, 1988). Wagner and Torgesen (1987) conclude from a review of the brief literature comparing phonological awareness, naming speed and memory that while there is some generality, each class of variable also contributes independent variance to reading. While the distinctiveness of a word's sounds or its phonological codes affects memory (e.g., see Siegal and Linder, 1984), whether this effect is related to phonological awareness is unknown.

Researchers have paid increasing attention to the type of reading measure used in studies. While measures of accuracy and speed of single word identification, phonics skill, and reading comprehension are certainly correlated, they do tap different skills as well. Some of the variability in results of studies may be due to the variability in reading measures. Reading comprehension tests, for example, are more complex than other measures, depending on analysis of meaning and memory (Curtis & Glaser, 1983) as well as word identification fluency (Perfetti, 1985). As indicated by Wagner & Torgesen (1987), we need to learn whether the several aspects of reading are related differentially to the issues discussed above.

The present study is part of a larger study of the development of automaticity of naming and accuracy of phonological awareness in poor and average readers. This paper will focus upon the phonological awareness, naming speed and rote memory correlates of different reading skills in a sample of grade 4 poor and average readers.

Method

Teachers in three grade 4 classes in a large elementary school were asked to nominate both children who had at least moderately severe problems in reading compared to age-expected performance, and children who read approximately at an age-expected level. No children were identified as having severe emotional problems or not speaking fluent English. Parental permission for participation in the study was sought for the poor readers, and for the subset of average readers for whom the distribution of sex, classroom, and previous group IQ scores were most similar to that of the poor readers. Twenty-eight grade 4 students took part in the study.

Tests administered assessed different aspects of reading as well as each of the proposed correlates of specific reading disability. The Peabody Picture Vocabulary Test-Revised (PPVT-R) (Dunn & Dunn, 1981) provided an estimate of verbal IQ in order to control for that variable in subsequent analyses. Children were seen individually for 30 to 45 minute sessions on two occasions early in the Fall.

Reading comprehension was assessed by The Canadian Test of Basic Skills (King, 1976), a group achievement test which had been administered to the students a few months prior to the study (at the end of Grade 3).

Accuracy of single word reading and of nonsense word decoding were assessed by two subtests of the Woodcock Reading Mastery Test (Woodcock, 1973), Word Identification and Word Attack, administered to each child individually.

Naming Speed was assessed by digit and letter continuous naming tasks similar to those devised by Denckla and Rudel (1976). Children were asked to say the names of 48 single syllable digits as quickly as they could without making mistakes. Six digits repeated eight times in semi-random order were printed in 6 rows of eight items. Children also named 48 capital letters as quickly as they could. A similar arrangement of six letters repeated eight times was presented to them. Two trials of each naming test were given and the score was the mean items per second across two trials.

Three phonological awareness tests were administered:

a) The Auditory Analysis Test (Rosner & Simon, 1971) is a sound deletion test which discriminates between good and poor readers across a relatively large age range. It was adapted and shortened for this sample. Items include deletions of first or later consonants of a consonant blend, or the end consonant. For example, the examiner says, "Say block". The child repeats block. The examiner continues, "Now say block without the /b/". The score is the total correct out of 24 items.

b) The Odd Word Out task of Bradley & Bryant (1978) is a sound categorization task which has discriminated dyslexic and good readers in several studies (Bryant & Bradley, 1985). The examiner says four words (e.g., sun, see, sock, rag) at the rate of one per second. The child has the task of telling which word does not belong with the other three on the basis of its sound. Three of the words may begin with the same sound, have the same medial sound, or end with the same sound.

c) The third phonological task was adopted from Snowling (1981). Children were asked to repeat three and four syllable real and nonsense words pronounced by the examiner. The nonsense words were analogous to real words in the list. For example, the child was asked to say both "magnificent" and "bagmivishent"; each accurate repetition earned a point. Words and non-words were presented in mixed order. Snowling (1981) reports that accuracy of non-word repetition discriminated reading groups. In the current sample, there is a strong ceiling effect on the total score. The score for the most difficult part, four-syllable non-words, suffers that effect a bit less strongly, and it is those scores which are analyzed here.

Short term memory was assessed by the Digit Span subtest from the WISC-R (Wechsler, 1974). For purposes of this study, the raw score from the Digits Forward portion of the test was used, since it is deficits in this skill which have characterized disabled readers in other studies.

Results

While 28 Grade 4 children were tested, the data for one poor reader was dropped from analyses because the PPVT-R score was below 85. Table 1 describes the characteristics of the 14 children designated by their teachers as poor readers and the 13 children whose reading was considered at least average by their teachers. The reading scores of the groups are significantly different. Although many of the poor readers would not be called dyslexic by a strict criterion, most of them were reading a year or more below their age expected level. The groups also differ on PPVT-R estimates of general verbal ability and therefore these scores are statistically controlled in all subsequent analyses.

Insert Table 1

Intercorrelations of the measures (Table 2) reveal that the phonological tasks (i.e., AAT, Odd Word Out and Snowling tests) are not significantly related to one another in this sample, but that all are related to aspects of reading. Digit and letter naming speed are highly intercorrelated, with digit naming speed (DNS) having the higher relationship to reading. Digits, the symbols named most often in daily life by both good and poor readers, may best tap the ability to achieve automaticity of naming more generally. If DNS is statistically controlled, letter naming speed contributes no additional variance to reading, so DNS is used in subsequent analyses. DNS, Digit Span, and Odd Word Out are intercorrelated, but are unrelated to the other phonological awareness scores.

Insert Table 2

Hierarchical regression analyses were conducted in order to tease out independent sources of variation which contribute to the three types of reading scores. PPVT-R standard scores were entered at the first step (Table 3). When entered at Step 2, DNS accounted for significant new variance in the three reading tests. The phonological tests each contributed variance to reading individual words and nonwords when entered at Step 2, and Digit Span also contributed at this step. To determine if the phonological tests contributed significant variance independent of naming speed, separate analyses were run, with each of these tasks entered at Step 3, after DNS. As apparent in Table 4, the Odd Word Out task was no longer significantly related to any reading subtest when entered after PPVT-R and DNS, but both the sound deletion (AAT) and the nonword repetition (Snowling) tests continued to predict substantial variance in word and non-word reading scores. Clearly, the AAT and Snowling Repetition test tap important variance independent of naming automaticity.

Insert Table 3

Insert Table 4

Whether naming speed also contributes variance independently of phonological tasks was investigated by reversing the order of entry used in the above analyses, i.e., by entering the phonological tasks at Steps 2 and 3, and DNS at Step 4. It may be seen in Table 5 that DNS continues to predict all three reading tasks significantly; it is an especially strong predictor of CTBS score. The relative independence of the phonological tests from one another and from DNS while all are related to some aspects of reading leads to high multiple Rs for reading subtests.

Insert Table 5

The role played by short-term rote memory in reading difficulties was explored by entering Digits Forward score into the regression analyses. (See Table 6.) Again, when entered after PPVT-R, Digit Span contributed significant variance to all reading scores. In this instance, DNS did not contribute variance to word and non-word reading additional to that of Digit Span, but DNS did contribute additional variance to CTBS scores. Both AAT and Snowling Non-word Repetition contributed significantly to Word Identification and Word Attack after controlling for Digit Span, but the Odd Word Out procedure did not continue to predict any reading test. When the order of entry was reversed and Digit Span entered at Step 3 after naming speed (Table 4), Digit Span failed to predict significant further variance in reading.

Insert Table 6

Discussion

The most important result of this study is the finding that the Auditory Analysis Test, Snowling's Non-word Repetition test and Digit Naming Speed are each independent contributors to several types of reading tasks. Despite performances close to the test's ceiling, non-word repetition was strongly related to Word Identification and Word Attack scores. Few Grade 4 students are not proficient in the task of synthesizing unfamiliar speech and converting the pattern into a new speech-motor program. Those few who are not, however, are usually quite disadvantaged both in learning to identify new words and in decoding unfamiliar words. Quite another deficit is that revealed by the AAT. This is indeed a harder task for Grade 4 students, with even good readers making mistakes on it. The difficult job is that of analyzing the ongoing speech stream, isolating the phoneme indicated, and then synthesizing the rest of the stream. It is easy to imagine how students who have difficulty on

this auditory task might also have difficulty on the visual task most resembling it, Word Attack, where sounds of visual symbols must be both analyzed and synthesized.

It is of interest that both phonological tasks are related only to individual word and non-word reading, and not to the broader CTBS reading measure which no doubt combines word identification with heavy demands for fluency, discourse analysis and memory. Naming speed, on the other hand, is related to all three reading measures. The automaticity of naming visual symbols then contributes variance to decoding above and beyond auditory analysis and synthesis skills, and automaticity plays a strong role in reading comprehension.

The strong relationship between memory span and naming speed confirms some findings in the literature (Spring & Perry, 1983), but is stronger than the modest correlation found in a previous study in our lab (Bowers, Steffy & Tate, 1988). Future work will have to determine the parameters (eg., age, type of IQ control) regulating the size of this relationship. Whatever its size, the arguments of Dempster (1981) are compelling. He feels that an important determinant of memory span and of its relationship to learning disabilities is speed of item identification. The interrelationships of Bradley & Bryant's Odd Word Out task, Naming Speed and Digit Span suggest that a task with a rote memory component will have at least some overlapping variance with item identification speed and correlate with various reading tasks, especially comprehension. At the same time, the relative lack of relationship between the phonological tasks and memory and naming speed variables suggests that there are distinct processing requirements for single word identification tasks. In the present study, the ability to analyze and to synthesize phonological information affected individual word and nonword reading independently. The differences among the predictors of reading may be more fruitful to emphasize than the idea that name or sound codes are utilized in all.

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Table 1

		Poor Readers N = 14	Average Readers N = 13	t	p
IQ Estimates	PPVT-R	100.2 (2.9)	107.3 (6.6)	2.72	<.05
Reading	Word Identification	28% (17%)	54% (18%)	3.75	<.001
	Word Attack	27% (19%)	49% (23%)	2.69	<.05
	CTBS Grade[a]	2.5 (.5)	4.0 (.5)	7.83	<.001
Naming Speed items/sec.	Digit Naming Speed	1.85 (.26)	2.14 (.36)	2.41	<.05
	Letter Naming Speed	1.77 (.22)	1.97 (.43)	1.48	n.s.
Phonological Tasks	Auditory Analysis Test	9.14 (6.44)	16.15 (5.83)	2.96	<.01
	Odd Word Out	22.43 (2.79)	25.46 (3.62)	2.45	<.05
	Snowling: Total/32	29.64 (2.13)	30.08 (1.38)	.62	n.s.
	Snowling: 4 syllable nonword/8	6.43 (1.45)	6.77 (.83)	.74	n.s.
Memory	Digit Span Forward	4.57 (1.60)	6.23 (2.65)	1.99	<.1

[a]Test administered at end of Grade 3

Table 2

Intercorrelation of Measure

	PPVT	WID	WATK	CTBS	AAT	Snowling	Odd Word	DNS	LNS	Digit Span
PPVT	X	.53**	.46**	.35**	.38*	.28	.27	.06	.13	.04
WID		X	.92***	.62***	.70***	.53**	.48**	.51**	.38*	.47**
WATK			X	.45**	.66***	.54***	.36*	.43*	.32	.46**
CTBS				X	.46**	.10	.53**	.61***	.47**	.50**
AAT					X	.10	.18	.24	.07	.18
Snowling						X	.20	.13	.17	.23
Odd Word							X	.40*	.44*	.45**
DNS								X	.85***	.79***
LNS									X	.68***
Digit Span										X

* p<.05
** p<.01
*** p<.001

Table 3

Regression Analyses Predicting Reading

Variables	Step	Word Identification		Word Attack		CTBS	
		R	R^2_{cha}	R	R^2_{cha}	R	R^2_{cha}
PPVT	1	.53	.28**	.46	.21*	.35	.12
DNS	2	.71	.23**	.61	.16*	.68	.34***
AAT	2	.75	.29***	.70	.28**	.49	.12
Snowling	2	.66	.16*	.63	.19*	.35	.00
Odd Word	2	.63	.12*	.52	.06	.57	.21*
Digit Span	2	.69	.20**	.63	.19*	.60	.23**

* p<.05
** p<.01
*** p<.001

Table 4

Regression Analyses Controlling DNS

Variables	Step	Word Identification		Word Attack		CTBS	
		R	R^2_{cha}	R	R^2_{cha}	R	R^2_{cha}
PPVT	1	.53	.28**	.46	.21*	.35	.12
DNS	2	.71	.23***	.61	.16*	.68	.34***
AAT	3	.84	.19***	.76	.20**	.72	.05
Snowling	3	.79	.12**	.72	.15*	.69	.00
Odd Word	3	.73	.03	.62	.01	.73	.06
Digit Span	3	.72	.01	.64	.04	.68	.00

* p<.05
** p<.01
*** p<.001

Table 5

Regression Analyses

Variables	Step	Word Identification		Word Attack		CTBS	
		R	R^2_{cha}	R	R^2_{cha}	R	R^2_{cha}
PPVT-R	1	.53	.28**	.46	.21*	.35	.12
Snowling	2	.66	.16*	.63	.19*	.35	.00
AAT	3	.85	.29***	.82	.28***	.49	.12
DNS	4	.91	.10**	.86	.06*	.72	.27**

* p<.05
** p<.01
*** p<.001

Table 6

Regression Analyses Controlling Memory

Variables	Step	Word Identification		Word Attack		CTBS	
		R	R^2_{cha}	R	R^2_{cha}	R	R^2_{cha}
PPVT-R	1	.53	.28**	.46	.21*	.35	.12
Digit Span	2	.69	.20**	.63	.19*	.60	.23**
DNS	3	.72	.04	.64	.01	.68	.11*
AAT	3	.83	.21***	.78	.21**	.65	.07
Snowling	3	.76	.09*	.72	.12*	.61	.01
Odd Word	3	.71	.03	.64	.00	.65	.07

* p<.05
** p<.01
*** p<.001

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Naming Speed and phonological awareness: Separable roles in reading disability.

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Reading disabled children differ from normal readers on tasks tapping phonological awareness, automaticity of name retrieval, and memory span. How independent these variables are is unclear. As part of a study of the developmental course of deficits in these skills, and their role in reading disabilities, 13 average and 14 poor readers from several Grade 4 classrooms, were given various tests of digit and letter naming speed, phonological awareness and digit span. Among reading skills assessed were single word identification, word attack and reading comprehension. Scores on a test of verbal ability were statistically controlled in hierarchical regression analyses. Results indicated that digit naming speed, phonological awareness and short term memory contributed variance to reading skills. However, phonological awareness tests were not intercorrelated and, with one exception, did not correlate with tests of naming speed or memory. Multiple regression coefficients for each reading score were very high. Both analytic and synthetic use of speech sounds contributed independent variance to single word and non-word reading, but not to comprehension, while digit naming speed was strongly related to comprehension and only moderately to the other reading tests. Memory span shared considerable variance with naming speed. Use of a multivariate model of reading disability in which several aspects of reading are assessed in conjunction with multiple predictors, demonstrated the specificity of effects and the additive nature of problems.

Regression Analyses

Variables	Step	Word Identification		Word Attack		CTBS	
		R	R^2_{cha}	R	R^2_{cha}	R	R^2_{cha}
PPVT-R	1	.53	.28**	.46	.21*	.35	.12
Snowling	2	.66	.16*	.63	.19*	.35	.00
AAT	3	.85	.29***	.82	.28***	.49	.12
DNS	4	.91	.10**	.86	.06*	.72	.27**

* p<.05
**p<.01
***p<.001